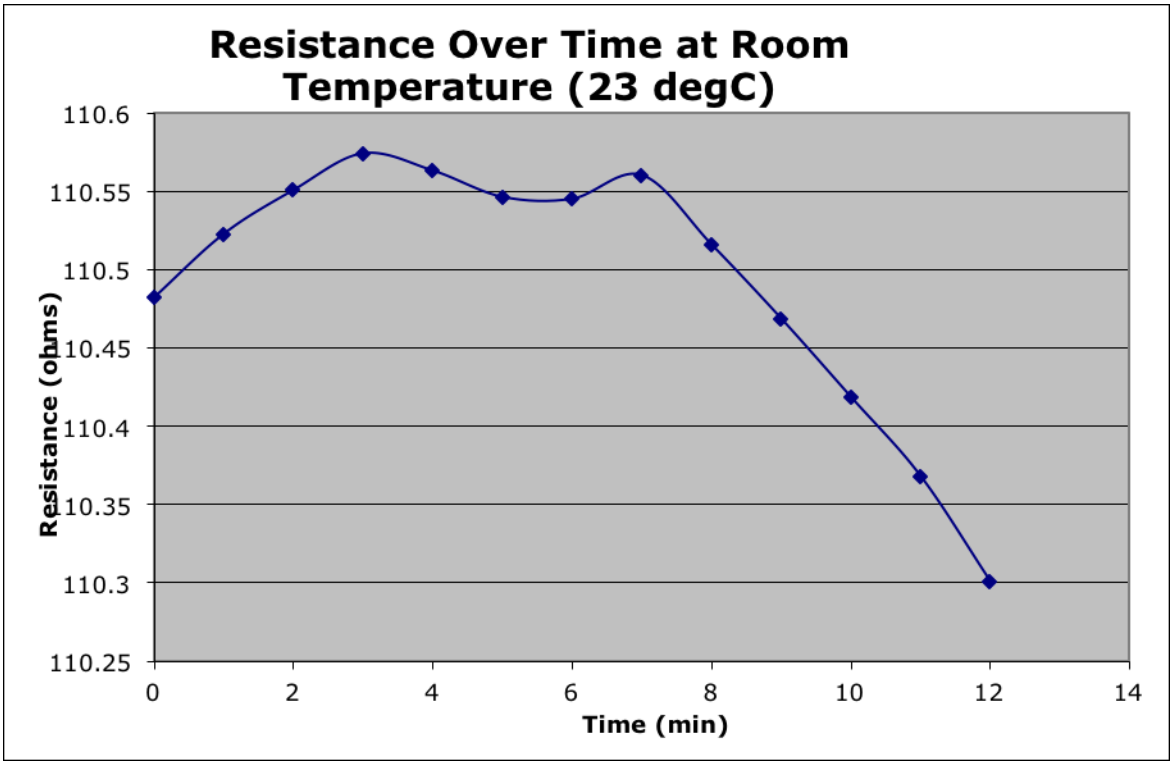
RTD Data

This data was obtained using a Keithley 196 DMM Multimeter and three Class B RTDs. Data for temperatures above room temperature was obtained by placing the RTDs in an oven and adjusting the temperature. The low temperature data was obtained by placing the RTDs in liquid Nitrogen, and moving them to the desired height in and above the LN_2 level. The motivation for taking these measurements was to test the accuracy of the RTDs. They will eventually be used in the LAPD experiment to measure the temperature gradient in the tank.

Room Temperature Data:

Time (min)	Resistance (ohms)
0	110.4823
1	110.5228
2	110.5508
3	110.5742
4	110.5632
5	110.5464
6	110.5452
7	110.5603
8	110.516
9	110.4687
10	110.4187
11	110.3682
12	110.3011



Analysis:

The RTD's resistance reading was the most consistent when read between about 1 and 8 minutes. Before one minute, the RTD's temperature begins to rise, thus leading to the steep increase in resistance. After this time frame, the resistance began to fluctuate.

Resistance Data with Known Temperature:

Temp (degC)	Resistance 1 (Ohms)	Resistance 2 (Ohms)	Resistance 3 (Ohms)	Average	σ
26	110.1704	110.2731	110.1267	110.1901	0.075155
30	111.3453	111.4638	111.3263	111.3785	0.074509
40	115.4732	115.6045	115.5326	115.5368	0.065749
50	119.1027	119.223	119.0943	119.14	0.072003
60	123.3417	123.4838	123.3945	123.4067	0.071827
70	127.3224	127.4727	127.3968	127.3973	0.075151
-196	20.88	20.73	20.73	20.78	0.086603

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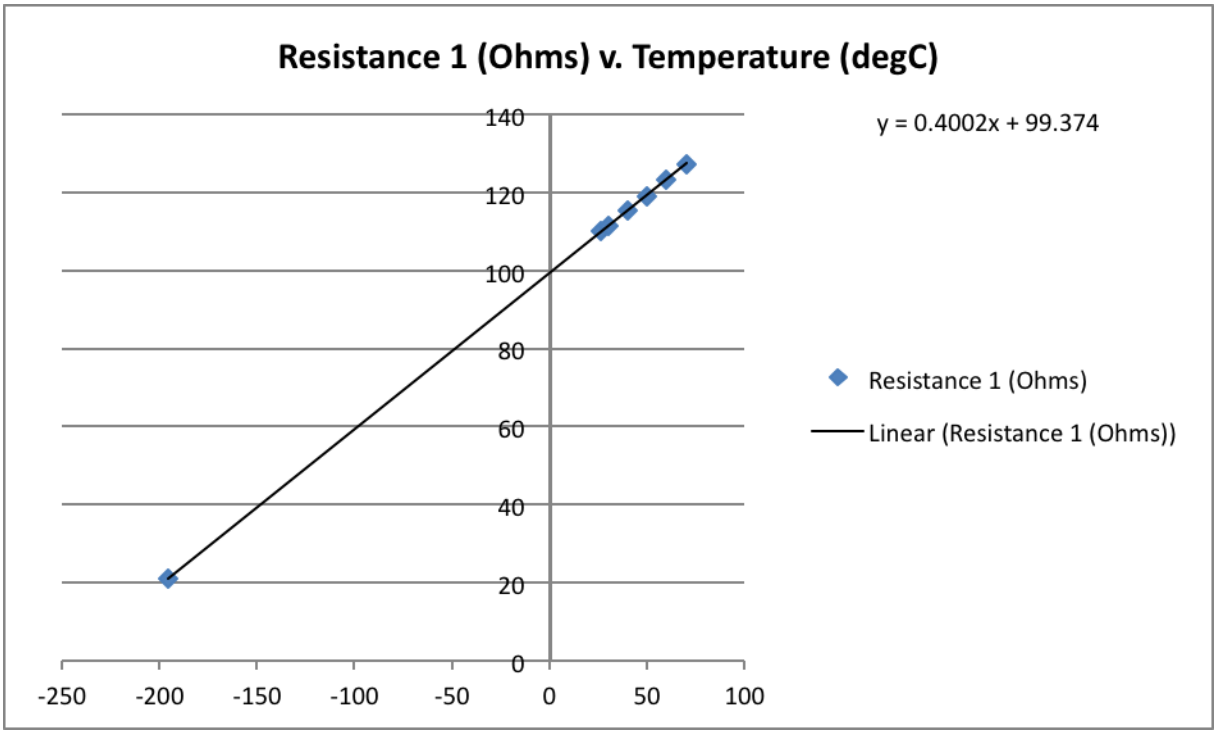
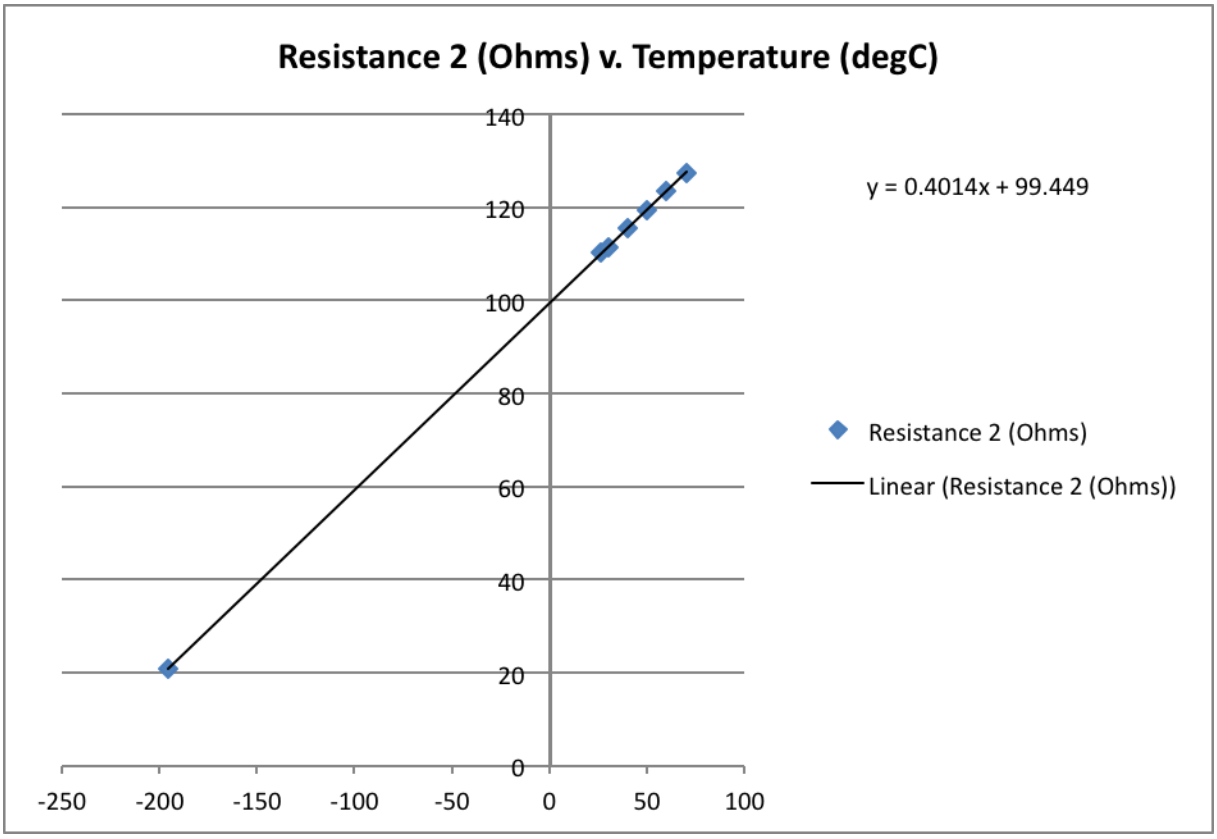
60	123.3417	123.4838	123.3945
70	127.3224	127.4727	127.3968
-196	20.88	20.73	20.73

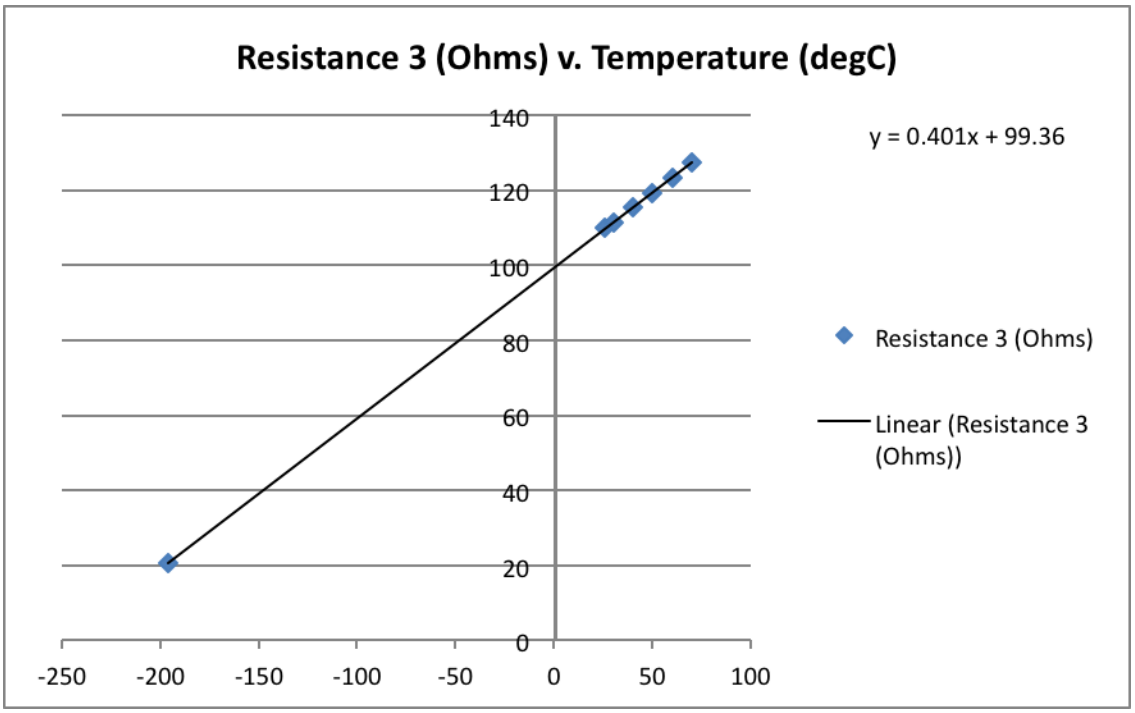
These measurements were made using an oven to gradually increase the temperature of the RTD, then cooling the RTD in liquid Nitrogen.

Time (s)	Resistance (Ohms)	Current (mA)	Power (W)	Heat (Joules)	Calculated Temp (degC)	Thermal Mass (J/degC)
0	110.4823	1.7	0.000319294	0	27.73640898	0.250988033
60	110.5228	1.7	0.000319411	0.019164654	27.83740648	
120	110.5508	1.7	0.000319492	0.038339017	27.90723192	
180	110.5742	1.7	0.000319559	0.057520699	27.96558603	

Using the equations $P=I^2R$ and $Q=C_{TH}\Delta T$ the power input, heat input, and thermal mass was calculated (See table above). Using the thermal mass and the heat input, it was found that the for the first 3 minutes the RTD was being used, the temperature rose at a rate of .001273 ^{o}C/s.


Resistance 1 (Ohms) v. Temperature (degC)
y = 0.4002x + 99.374
140
120
100
80
60
40
20
0
-250
-200
-150
-100
-50
0
50
100
Resistance 1 (Ohms)
Linear (Resistance 1 (Ohms))


Resistance 2 (Ohms) v. Temperature (degC)
y = 0.4014x + 99.449
140
120
100
80
60
40
20
0
-250
-200
-150
-100
-50
0
50
100
Resistance 2 (Ohms)
Linear (Resistance 2 (Ohms))



Analysis:

The equations displayed on the graphs were creating assuming that the change of resistance due to the temperature was linear. The equations for all three RTDs were very similar. Using these equations we can determine the temperature of the RTD's surroundings at various points in the vessel. Using these results we found that the RTDs were changing at a relatively constant rate of 2.5 degrees C per Ohm.

Location (in. above LN2)	R1 (Ohms)	R2 (Ohms)	R3 (Ohms)	Temp1 (degC)	Temp2 (degC)	Temp3 (degC)
1	33.68	32.15	32.49	-164.1529235	-167.7628301	-166.7581047
2	37.56	36.49	36.72	-154.4577711	-156.9506726	-156.2094763
3	43.48	42.55	41.23	-139.6651674	-141.8535127	-144.9625935
4	54.06	53.61	54.05	-113.2283858	-114.2999502	-112.9925187
5	56.23	55.56	55.49	-107.806097	-109.4419532	-109.4014963
6	61.84	61.19	61.16	-93.78810595	-95.41604385	-95.26184539

These temperature results are consistent with our expectations. The resistance of the 3rd RTD was measured first each time, which causes it to consistently have the lowest temperature, which means the 1st and 2nd RTD will have a slightly higher temperature each time.

Calculated Temp R1 (degC)	Calculated Temp R2 (degC)	Calculated Temp R3 (degC)	Measured Temp (degC)	Deviation from linear R1	Deviation from linear R2	Deviation from linear R3	Average
26.97751124	26.86372696	26.84962594	26	0.977511244	0.863726956	0.849625935	0.896955
29.91329335	29.83009467	29.84114713	30	0.086706647	0.169905331	0.158852868	0.138488
40.22788606	40.14573991	40.33067332	40	0.227886057	0.14573991	0.330673317	0.234766
49.29710145	49.16043847	49.2127182	50	0.702898551	0.839561535	0.787281796	0.776581
59.88930535	59.7752865	59.93640898	60	0.110694653	0.224713503	0.063591022	0.133
69.83608196	69.71275536	69.91720698	70	0.163918041	0.287244644	0.082793017	0.177985

Standard deviation of the average: 0.347779

Conclusions:

The RTDs measured very closely follow a linear fit. The temperature rises at a rate of .001273 degC for the first 3 minutes of operation, and then is steady until around the 8 minute mark.